# Quark-Gluon Plasma Signatures*

*R. Vogt*

Part of the LHC experimental program will be devoted to heavy-ion collisions such as Pb+Pb at $\sqrt{s} = 5.5$ TeV per nucleon pair, the highest energy available for these collisions. We focus on possible signature of quark-gluon plasma formation that can be observed with CMS. Two of the most interesting proposed signatures involving hard processes are quarkonium suppression and manifestations of energy loss of fast partons in the medium. A major advantage of the CMS detector is that it is possible to measure both within the same experiment.

Some of the most prominent quark-gluon plasma signatures that could be studied with the CMS detector are discussed. Since the relative importance of these signatures depend on the initial conditions of the system, the role of minijet production in determining the initial conditions was described. Parton shadowing, which influences the initial temperature and the final multiplicity in an ideal quark-gluon plasma, was included. It was found that shadowing could reduce the initial temperature by decreasing the initial parton production. This reduction in the multiplicity would have the effect of making the environment easier to handle experimentally since the number of particles to be tracked would be reduced.

Quarkonium suppression through the $\Upsilon$ family is a promising signature, as already known from fixed-target experiments at the CERN SPS. The $p_T$ dependence of the $\Upsilon'/\Upsilon$ ratio, as measured by CMS, could provide valuable information on the initial conditions of the plasma. As was shown, the initial conditions and the subsequent expansion of the system strongly influence the $\Upsilon'/\Upsilon$ ratio. The $\Upsilon$ production rate is large enough for such measurements to be feasible. The $\psi'/\psi$ ratio as a function of $p_T$ can provide additional important information on the plasma even at high $p_T$.

Energy loss effects such as the modification of the dilepton continuum through heavy quark decays and jet quenching will provide complementary information on the density of the medium traversed by the hard partons as well as the influence of energy loss on global variables. The size of the energy loss influences the relative charm and bottom contribution to the dilepton continuum and the monojet to dijet ratio at high $E_T$. Both effects are observable by CMS. The CMS detector is particularly well suited for measuring high $E_T$ jets.

Finally, it is important to note that any conclusions regarding quark-gluon plasma production depend on correlating as many signatures as possible. To understand the systematics of plasma production, studies of other systems at more than one energy will be crucial. To establish a baseline, $pp$ and $p$Pb collisions at the same energy as the Pb+Pb collisions are strongly advised. Going down in energy to *e.g.* the Tevatron energy of 1.8 TeV could provide an important cross check. Comparison of the Pb+Pb results with other nuclear systems such as Ca+Ca will also be important for a study of finite volume effects. Another necessary cross check for CMS will be comparison with results from the dedicated heavy-ion detector ALICE whenever possible since controversial results require confirmation, as already evident from the fixed-target heavy-ion program. Lessons learned from the CERN SPS heavy-ion program and the lower energy collider studies at RHIC should be put to good use as well.

*LBNL-42040, CMS NOTE 198/061, to serve as introduction to the document 'Heavy Ions in CMS'.